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U.S. PATENT APPLICATION

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Invention: MOTOR DRIVEN FUEL PUMP HAVING IMPELLER

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MOTOR DRIVEN FUEL PUMP HAVING IMPELLER

CROSS REFERENCE TO RELATED APPLICATION

The present application is based on and claims priority from Japanese Patent Application 2003-90910, filed March 28, 2003, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a motor driven fuel pump mounted in a fuel tank of an internal combustion engine (hereinafter referred to as engine).

2. Description of the Related Art

A fuel pump that has a fuel pressurizing passage and an impeller to boost pressure of fuel is well known and disclosed, for example, in JP-B2-3052623. Such a fuel pump is comprised of a suction-side cover in which a portion of the fuel pressurizing passage is formed.

In order to reduce the production cost and weight, many trials to change material of the suction-side cover from a metal to a resin has been made. However, if a resinous suction-side cover 94 is fixed to a cylindrical metal housing 92 by clinching the edge of the housing 92 as shown in Fig. 7, the resinous suction-side cover 94 easily deforms, resulting in that the suction-side cover 94 interferes with an impeller 96. The resinous suction-side cover 94 may creep under continuous pressure from the housing in a long period of time, resulting in loosening of the suction-cover.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide an inexpensive and lightweight fuel pump that has a resinous suction-side cover and is free from the above described problem.

According to a feature of the invention, a fuel pump for an internal combustion engine includes a suction-side cover having a fuel inlet, an exhaust-side cover having a fuel outlet, an electric motor, a pump casing disposed between the electric motor and the suction-side cover, a passage member having a pressure boosting passage disposed between the suction-side cover and the pump casing, an impeller disposed in the pressure boosting passage to be rotated by the electric motor and a cylindrical housing for accommodating the suction-side cover, the pump casing and the impeller. In the above fuel pump, the suction-side cover is made of a resinous member that has a shoulder having a round surface in contact with a portion of the cylindrical housing that is clinched at the shoulder.

Therefore, the stress concentration on the suction-side cover becomes smaller and creeping of the suction-side cover can be prevented. As a result, the suction-side cover can be prevented from loosening.

In the above described fuel pump, the round surface is preferably disposed at a peripheral surface of the suction-side cover away from the pump casing. Further, the radius of the round corner is preferably 2mm or longer. The portion of the cylindrical housing that is clinched may have a surface formed by a punch that has a concave pressing surface. It is more preferable that the shoulder has a thickness between 4 mm and 5 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and char acteristics of the present invention as well as the functions of related parts of the present invention will become clear from a study of the following detailed description, the appended claims and the drawings. In the drawings:

Fig. 1 is an axial cross-sectional view of a fuel pump according to a preferred embodiment of the invention;

Figs. 2A, 2B and 2C respectively illustrate a front view of a suction-side cover, a cross-sectional view of the suction-side cover cut along line IIB-IIB in Fig. 2A, and a rear view of the suction-side cover;

Fig. 3 illustrates a step of fixing the suction-side cover to a housing of the fuel pump;

Fig. 4 is a graph showing a relationship between the amount of deformation of the suction-side cover and the radius of a pressing surface of a punch for fixing the suction-side cover to the housing of the fuel pump;

Fig. 5 is a graph showing the amount of deformation of the suction-side cover fixed by a punch having a curved surface;

Fig. 6 is a graph showing the amount of deformati on of the suction-side cover fixed by a punch having a flat conical surface; and

Fig. 7 is a schematic diagram showing a conventional step of fixing a suction-side cover to a cylindrical cover.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A fuel pump according to a preferred embodiment of the invention will be described with reference to the appended drawings.

As shown in Fig. 1, a fuel pump 10 according to a preferred

embodiment of the invention is a so-called in-tank type fuel pump to be mounted in a fuel tank of a vehicle.

The fuel pump 10 includes a cylindrical metal housing 22, which has a pair of annular steps 20, 30 at the inside surface thereof. The housing 22 accommodates an exhaust-side cover 14, an electric motor 46, a pump casing 40, an impeller 37, a suction-side cover 36, etc.

The exhaust-side cover 14, which has a front surface and a shoulder portion, is fitted to the housing 22 so that the front surface engages the annular step 20. The housing 22 has one end through which the exhaust-side cover 14 is inserted and fixed by clinching the edge of the one end to hold a shoulder portion of the exhaust-side cover 14, thereby positioning the exhaust-side cover 14 between the annular step 20 and the one end. The electric motor 46 has a rotary shaft 45, which is supported by the exhaust-side cover 14 via a bearing 16. The housing 22 has an inner wall, on which four semi-cylindrical permanent magnets 44 are disposed in a circular line. The permanent magnets 44 are magnetized in radial directions to alternately form N and S poles in the circumferential direction.

The electric motor 46 has an armature 42 which is rotatably accommodated in the housing 22 and a commutator 18 which is fixed to one end of the armature 42. The armature 42 includes a magnetic core 24 to which the rotary shaft 45 is force-fitted and a plurality of coils 28 each of which is wound around a bobbin 26. The commutator 18 has a plurality of commutator segments each of which is connected to one of the coils 28.

The pump casing 40 is inserted into the other end of the housing 22 and engages the annular step 30 by an inside surface thereof. The

pump casing 40 has an annular peripheral portion at an outside surface thereof and a center hole to which another bearing 38 is fitted. The annular peripheral portion engages the suction-side cover 36 at the inside surface of the suction-side cover 36. The suction-side cover 36 has a shoulder 34 at the peripheral portion, which is held by a portion of the other end of the housing 22 that is clinched to fix the suction-side cover 36 to the housing 22, thereby positioning the pump casing 40 between the annular step 30 and the suction-side cover 36. A pressure boosting passage 32 is formed at a space between the inside surface of the suction-side cover 36 and the outside surface of the pump casing 40 so that the impeller 37 can rotate therein. The impeller 37 is a disk member that has a plurality of blade-ditches on the periphery thereof.

When the electric motor 46 rotates along with the rotary shaft 45 to rotate the impeller 37, fuel that is supplied from the fuel inlet to the pressure boosting passage 32 is pressurized and discharged from the pressure boosting passage 32 to the inside of the electric motor 46 through a connecting passage 29. The discharged fuel cools the electric motor 46 and flows out from the fuel outlet 12 to be supplied to an engine.

The suction-side cover 36 is a resinous disk plate that has a plurality of depressions 54 for preventing mold shrinkage and the shoulder 34 at its periphery. The suction-side cover 36 also has a C-shaped groove 50 that is a portion of the pressure boosting passage. The fuel inlet 52 is formed at an end of the C-shaped groove 50, and a vapor purging hole 48 is also formed in the C-shaped groove 50.

The suction-side cover 36 has a thickness of t1, such as 7 mm. The shoulder 34 has a thickness of t2 and a round corner of more than 2 mm in radius r2. The round corner provides a contact surface in contact

with the end of the housing 22. The more the radius of the round corner increases, the less stress concentration on the contact surface. As the stress concentration becomes smaller, creeping of the suction-side cover 36 can be prevented or reduced. As a result, the suction-side cover 36 can be prevented from loosening. However, as the suction-side cover 36 becomes thicker, the total length of the fuel pump 10 increases. Therefore, the ratio of the thickness t2 of the shoulder 34 to the thickness t1 of the suction-side cover 34 is preferably between 0.57 and 0.71.

The suction-side cover 36 is fixed to the housing 22 by a punch 56, as shown in Fig. 3. The punch 56 has a pressing surface 58 to press the end of the housing 22 against the shoulder 34 of the suction-side cover 36. The pressing surface 58 inclines to the center axis of the housing 22 by an inclination angle α. As the inclination angle α increases, the remaining stress to deform the suction-side cover 36 becomes smaller. However, if the inclination angle α becomes larger than 45 degrees, the housing 22 may buckle. Therefore, the inclination angle α is preferably about 30 degrees. The pressing surface is, preferably, concave that has a radius r1. It may be conical if the inclination angleα is appropriate.

The amount of the deformation of the shoulder 34A relative to the radius r1 of the concave pressing surface 58 when the suction-side cover 36 is fixed to the housing 22 at an end that has a thickness of 0.6 mm was tested to have a result shown in Fig. 4. If the radius r2 of the contact surface of the shoulder 34 is 1 mm, the amount of the deformation of the shoulder 34 is smaller in case the radius r1 of the pressing surface 58 is 2 mm or 3 mm. If the radius r2 of the contact surface of the shoulder 34 is 2 mm, the amount of the deformation of the shoulder 34 is smaller in case the radius r1 of the pressing surface 58 is 4 mm or 5 mm.

According to the result of an analysis, the following relationship was found: if the radius r1 of the pressing surface 58 is a length between 1.4 mm and 2.4 mm larger than the sum of the radius r2 of the shoulder 34 and the thickness of the housing 22, the deformation due to fixing by clinching becomes minimum; and if the radius r1 of the concave pressing surface 58 is between 2 and 5, the deformation of the shoulder 34 becomes smaller than the flat conical pressing surface.

A result of an analysis of the deformation at two portions P, Q (shown in Fig. 2B) of the suction-side cover 36 is shown in Figs. 5 and 6. When the housing 22 and the shoulder 34 are fixed by clinching the end of the housing 22, the suction-side cover 36 deforms so that the surface becomes convex in the direction away from the impeller 37. Therefore, the suction-side cover 36 will not interfere with the impeller 37. The amount of the deformation when fixing by the punch having the concave pressing surface was found smaller than that when fixing by the punch having the flat conical pressing surface.

In the foregoing description of the present invention, the invention has been disclosed with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made to the specific embodiments of the present invention without departing from the scope of the invention as set forth in the appended claims. Accordingly, the description of the present invention is to be regarded in an illustrative, rather than a restrictive, sense.